Musculoskeletal Complications of Diabetes

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Diabetes Facts

- Affects over 23.6 million people in the US, 7.8% of the population.
- The economic cost of diabetes in 2007 was estimated to be $174 billion.
- One out of every five health dollars is spent on someone with a diagnosis of diabetes.

Data from the American Diabetes Association website: [www.diabetes.org](http://www.diabetes.org)
Common MSK Complications of Diabetes

- Osteomyelitis
- Diabetic neuropathic arthropathy
- Tendonopathies (tendonitis, tendon rupture and tenosynovitis)
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- Osteomyelitis
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Patient EH: HPI and PMH

- Patient EH is a 45 year old male with a 20 year history of diabetes who presents in 2005 for an evaluation of his foot and ankle.
- He recently developed a wound and has been on intermittent periods of antibiotics.
- He does not recall any cultures taken recently.
- Physical exam shows a large wound on the lateral side of the right foot with good granulation tissue but which easily probes down to the bone.
- The ankle is edematous and erythematous.
Patient EH: R Lateral Foot Film (March 1999)

Source: PACS, BIDMC
Anatomy of the Foot

- Image 2 source: http://www.podcare.com/foot-anatomy.html
Patient EH: Right Lateral Foot X-Ray

Fragmentation and sclerosis with soft tissue swelling
Destruction of the calcanealtalar articulation
Demineralization of tarsal and metatarsal bones

Right Lateral Foot X-Ray
These findings are consistent with diabetic neuropathic arthropathy.

Source: PACS, BIDMC
Overview of Diabetic Neuropathic Arthropathy

- Characterized by abnormalities in the bone, ligaments, tendons, and cartilage resulting in the deformity of joints.
- Often involves weight bearing joints such as the ankle and midfoot.
- These abnormalities cause altered weight bearing and repetitive trauma to the area.
- Over time this results in erosion of chondral surfaces, subchondral sclerosis, joint effusions, subluxations, dislocations, fracture and fragmentation.
Related Terminology

- Charcot foot is often used to describe neuropathic arthropathy in diabetic patients.
- However, diabetes type I patients did not live very long in Charcot’s time (late 1800s), and diabetes type II was very rare.
- Thus Charcot’s descriptions of “Charcot joint” were almost exclusively patients with tabes dorsalis, as syphilis was common in that time.
- The term diabetic neuropathic arthropathy or neuroarthropathy is often preferred.
Pathogenesis of Neuroarthropathy

- Etiology is controversial.
- The “French theory” believes that the joint changes are due to damage to the trophic centers of the central nervous system that control nutrition of the bones and joints, resulting in atrophy of osseous and articular structures.
- The neurotraumatic theory argues that loss of deep sensation and proprioception results in relaxation of supporting structures. This allows recurrent injuries to occur leading to malalignment, erosion of chondral surfaces, subchondral sclerosis and eventually fracture, fragmentation and disorganization of the joint.
- There is also evidence for the neurovascular theory, which suggests that deficits in sympathetic vasoconstrictive tone causes hyperemia and increased osteoclastic bone resorption.
- Likely the etiology is a combination of neurotraumatic and neurovascular factors.
Pathogenesis of Neuroarthropathy vs Ulcer

C-fiber dysfunction
- Loss of pain and warm thermal perception
- Wasted interossei, hammer toes, dry scaly feet, decreased blood flow
  - Ulcer

Large-fiber dysfunction
- Loss of vibration and position sense
- Equinus, warm feet, increased blood flow, osteopenia
  - Neuroarthropathy

Different Presentations of Neuroarthropathy

- Neuroarthropathy can present in a variety of patterns:
  - Metatarsalphalangeal pattern
  - Lisfranc pattern
  - Talonavicular pattern
  - Medial column pattern
  - Articular disease around and dissolution of the talus
  - Insufficiency fractures and avulsion of the calcaneal tuberosity

Sagittal T2-weighted fat-suppressed image

An example of acute neuroarthropathy with edema and enhancement of the bones around the Lisfranc joint and intertarsal joints accompanied by periarticular enhancement and muscle edema.

Companion Patient 2: Neuroarthropathy on MRI

Sagittal T1-weighted image (A)
Sagittal T1-weighted, gadolinium-enhanced, fat-suppressed image (C)

An example of chronic neuroarthropathy with fragmentation and subluxation of the midfoot (arrows) and collapse of the arch of the foot. As a result of the collapsed arch, pressure and friction of the cuboid has caused the formation of an adventitious bursa (arrowheads).

Patient EH: Recap of HPI and PMH

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Suspicion of Osteomyelitis

- How should we proceed with this patient? What tests should we order?
- If we suspect osteomyelitis, how should we proceed?
Overview of Osteomyelitis

- Infection of the bone or bone marrow.
- Three main etiologies:
  - The bone is seeded via hematogenous spread of organisms.
  - Through spread of a local infection such as cellulitis or penetrating ulcers (very common in diabetics).
  - Iatrogenic causes: hardware, surgeries etc.
- In adults the organism responsible is usually *S. aureus* and occasionally *Enterobacter* or *Streptococcus* species.
- In diabetes, osteomyelitis should be suspected when there is an ulcer that penetrates down to the bone.
Menu of Tests to Evaluate Osteomyelitis

- Plain Radiograph
- MRI
- CT
- Radionuclide Bone Scan
First let’s look at the general advantages and disadvantages of each modality.
Plain Radiograph

- Advantages:
  - Excellent resolution
  - Good visualization of osseous structures, joint spaces, fractures, loose bodies, chondrocalcinosis, osteophytes and enthesophytes
  - Fast
  - Cheap

- Disadvantages:
  - Poor visualization of soft tissues
  - 2D composite of 3D structures
MRI

- **Advantages:**
  - Good soft tissue visualization
  - Great for looking at effusions, muscle edema, bone marrow edema, tendon and ligament injuries, cysts or abscesses, damage to cartilage, tumors and osteonecrosis
  - No radiation

- **Disadvantages:**
  - Expensive
  - Takes a long time
  - Contraindicated in patients with certain metal implants
  - Possibility of nephrogenic systemic fibrosis in patients with renal failure
CT

- Advantages:
  - 3D reconstructions available
  - Great for visualizing small fractures, bone fragments, calcifications, periosteal reactions
  - With contrast can visualize cysts and some soft tissues

- Disadvantages:
  - More radiation
  - More expensive than plain film
  - Contraindicated in patients with contrast allergy or renal failure
Radionuclide Bone Scan

○ Advantages:
  ○ Can identify areas of increased activity, i.e. neoplasms, infections, healing fractures

○ Disadvantages:
  ○ Poor resolution, limited anatomic detail
  ○ Difficult to differentiate between the different active processes listed above
Modalities for Diagnosis of Osteomyelitis

- Plain radiograph has high specificity but low sensitivity. CT can show neuroarthropathy but is not helpful in the diagnosis of osteomyelitis. MRI is the test of choice for diagnosis of osteomyelitis in the setting of neuroarthropathy.

- MRI has a sensitivity and a specificity over 90% for the diagnosis of osteomyelitis. The specificity is lower in the setting of neuroarthropathy, but it is still the modality of choice.

Osteomyelitis on Plain Radiograph

- High specificity but low sensitivity.
- Often normal in the early stages of osteomyelitis.
- After two weeks, local reduction in bone density, periosteal reaction and osteolysis may be visible.

Companion Patient 3: Lateral Plain Film of the Left Foot

**Soft Tissue Gas**
- Enthesophytes at the attachment of the Achilles tendon and the plantar fascia

Lateral Left Foot X-Ray
- 74 year old diabetic man with suspected Osteomyelitis

Source: PACS, BIDMC
Companion Patient 3: Lateral and AP Plain Film of the Left Foot

Possible bony destruction of the medial 5th metatarsal head

Soft Tissue Gas
Enthesophytes at the attachment of the Achilles tendon and the plantar fascia

Lateral Left Foot X-Ray
74 year old diabetic man with suspected Osteomyelitis

Source: PACS, BIDMC
Diagnosis of Osteomyelitis on MRI

- Low bone marrow signal on T1.
- High bone marrow signal on T2.
- Periosteal reactions can be visualized as circumferential high signal on T2 with disproportionate enhancement.
- Secondary findings are useful to correlate with MRI, i.e. sinus tracts, skin ulceration, adjacent soft tissue infection, and periosteal reactions.

# ACR Recommendation for Patient EH

## Clinical Condition:
Suspected Osteomyelitis in Patients with Diabetes Mellitus

## Variant 6:
Neuroarthopathy with ulcer with exposed bone.

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<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
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<tr>
<td>MRI foot with contrast</td>
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<td>Radiographs and MRI are complementary. Both are indicated. See comments regarding contrast in text under “Anticipated Exceptions.”</td>
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<td>Radiographs and MRI are complementary. Both are indicated.</td>
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<td>NUC In-111 WBC scan and Tc-99m sulfur colloid marrow scan foot</td>
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</tr>
<tr>
<td>FDG-PET foot</td>
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<td></td>
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*Rating Scale: 1=Least appropriate, 9=Most appropriate*  

Source: ACR Appropriateness Criteria, [http://acsearch.acr.org](http://acsearch.acr.org)
Follow-up on Patient EH

- The patient already had a plain film from an outside institution that showed “significant disorganization and disintegration of the talus which may be either consistent with Charcot, osteomyelitis, or a combination of the two.”
- Cultures came back negative.
- Clinicians decided risk of osteomyelitis was low.
- The patient was scheduled for a CT to assess viability of fusion surgery.
Patient EH: Axial CT of Right Lower Extremity

- Extensive destruction of the talus
- Soft tissue and fluid intensity in the hindfoot
- Possible small pocket of gas in the posteriomedial ankle (green arrow)
- Subluxation of talar articulation with the navicular

Source: PACS, BIDMC
Patient EH: Sagittal CT of Right Lower Extremity

- Destruction of tibialtalar and subtalar joints
- Destruction of talar dome and most of posterior talus
- Soft tissue and fluid intensity centered around the talus
- Fragmentation of distal tibia
- Vascular Calcification

Source: PACS, BIDMC
Patient EH: DDx of CT Findings

- These findings may be due exclusively to neuropathic arthropathy, but osteomyelitis cannot be ruled out, especially with a potential gas pocket.

- It is very difficult to differentiate between acute neuroarthropathy and osteomyelitis, especially osteomyelitis in a patient with neuroarthropathy as they are both destructive processes.

- Clinical correlation may be helpful: fever, deep ulcers, pus etc.
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Osteomyelitis vs Neuroarthropathy

- **Location**
  - Neuroarthropathy often occurs in the midfoot.
  - Osteomyelitis starts distal to the Lisfranc joint or in the posterior calcaneous, but can spread to the midfoot.

- **On MRI**
  - Sinus tracts, replacement of soft-tissue fat, extensive or diffuse marrow abnormalities, thick rim enhancement or diffuse joint fluid enhancement and joint erosion support osteomyelitis superimposed upon neuroarthropathy.
  - Abnormal joint in a diabetic foot, preservation of subcutaneous fat, absence of soft-tissue fluid collections, presence of subchondral cysts, and presence of intraarticular bodies support neuroarthropathy without infection.


Compantion Patient 4: Osteomyelitis in the setting of Neuroarthropathy

Coronal T2-weighted fat-suppressed image (A)
Axial T1-weighted, gadolinium-enhanced, fatsuppressed image (D)

Image A shows dislocation and collapse of the talus (arrow) due to neuropathic involvement of the ankle. There is also a large joint effusion (arrowheads) and extensive surrounding bone marrow edema suggestive of Osteomyelitis.

Image D shows communication of the ankle joint and adjacent bones with a cutaneous ulcer (arrow) via sinus tracts (arrowheads).

Now back to Patient EH, who has good granulation tissue and negative cultures.
Patient EH: Treatment for Neuropathic Arthopathy

- Patient EH was followed and did not have osteomyelitis. He underwent a femoral head allogeneic graft using an intramedullary nail and external fixation frame.
Patient EH: Treatment Follow-up

- Fusion surgeries have high failure rates in diabetics due to poor healing and the persistence of neuropathic risk factors for arthropathy.
- In the picture on the right the intermedullary nail has been removed but pieces of two fractured screws were left in the foot.
- There is resorption of the superior portion of the femoral head graft.

**Resorption of the superior portion of the femoral head graft**

**Fractured portions of screws**

*Source: PACS, BIDMC*
Patient EH: 2 Years Later

- Patient RS presents 2 years later to the ER complaining of 4 days of fevers, chills, edema and erythema of the right lower extremity.

- Physical exam revealed 2 large abscesses and crepitation in the ankle.

- Patient had a surgical drainage and debridement of his right lower extremity but was healing slowly with persistence of edema and erythema.

- 2 months after his surgery an MRI was ordered to evaluate for osteomyelitis.
Patient EH: Axial MRI of Right Lower Extremity

Complex fluid collection with internal debris and calcification

Tracking of fluid into the medullary cavity of the distal tibia

Axial MRI w/o contrast of Right Lower Extremity

- There is a 6.4cm x 4cm complex fluid collection with internal debris and calcification.
- Possible tracking of the fluid into the medullary cavity of the distal tibia.

Source: PACS, BIDMC
Patient EH: MRI Findings

- The findings on MRI are strongly suggestive of osteomyelitis.
- However, clinical correlation reveals that the patient is not septic and his wound is granulating without pus.
- An acute osteomyelitis with abscess formation usually does not exhibit good granulation with absence of pus.
- The patient turned out not to have osteomyelitis.
- This highlights the difficulty in identifying osteomyelitis in the setting of neuroarthropathy and the importance of both radiological and clinical findings.
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Summary

- Diabetics are at risk for neurological and vascular abnormalities that increase their susceptibility for traumatic and neurovascular related injury to the bones, ligaments, tendons and cartilage of weight bearing joints.

- Overtime, there is erosion of the chondral surface and subchondral sclerosis followed by fracture, fragmentation, disorganization and destruction of the joint.

- Diabetics are also at increased risk for osteomyelitis, which can resemble neuropathic arthropathy on radiological studies.

- Diagnosis of osteomyelitis in the setting of diabetic neuroarthropathy is a difficult task, MRI findings and clinical correlation can help.
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References

1. American Diabetes Association website: www.diabetes.org